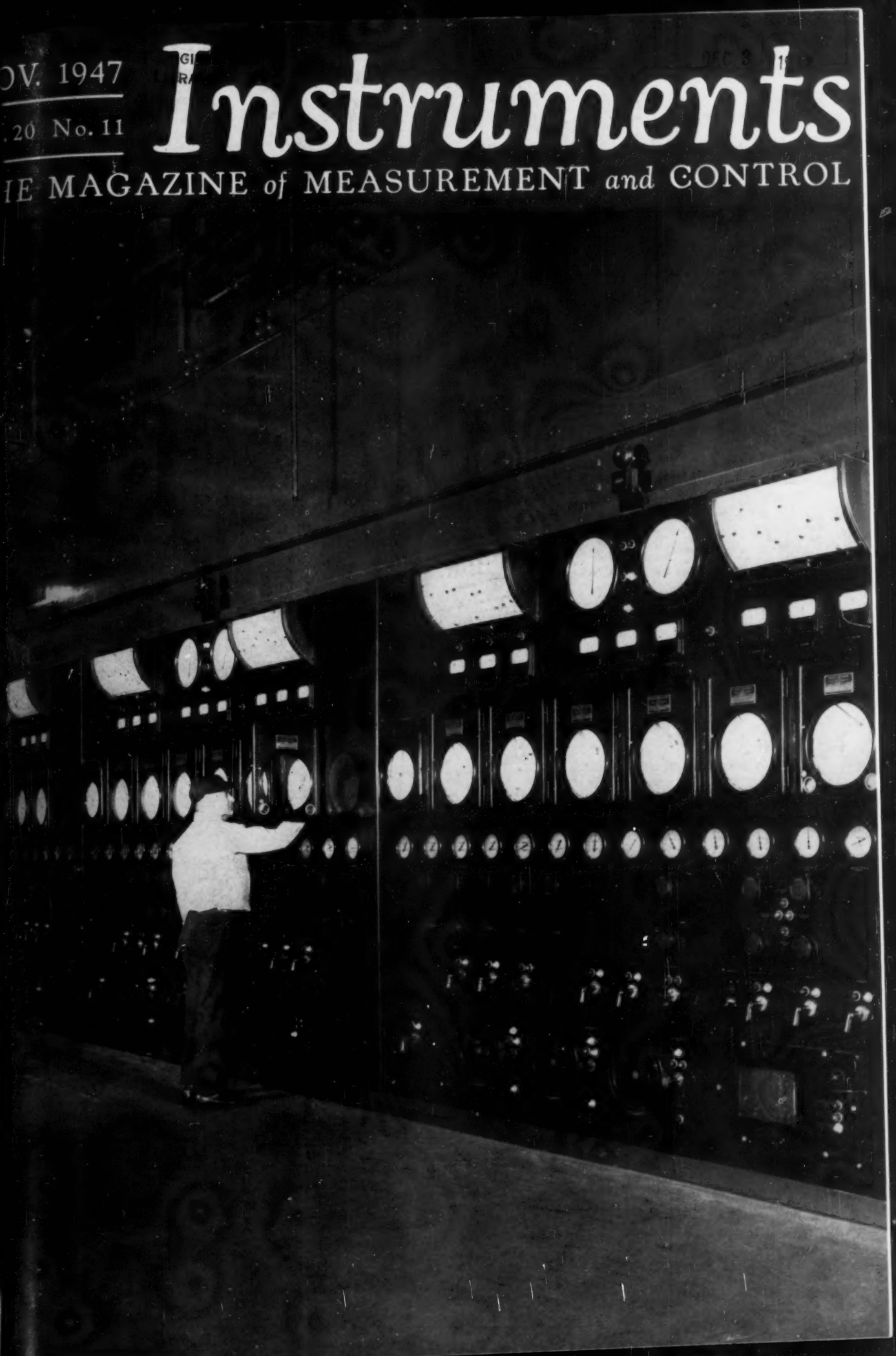
OV. 1947
.20 No. 11

Instruments

IE MAGAZINE of MEASUREMENT and CONTROL



"Speed is Important"

Speed is perhaps the greatest single factor in winning baseball. Star pitchers like Johnson . . . Matthewson . . . Alexander . . . are remembered by all baseball lovers chiefly because of their blinding speed—which paid off in wins time after time.

TAG CELECTRAY Pyrometers are FAST and ACCURATE

In batch or continuous heat treating processes, TAG CELECTRAY Recording Pyrometers have the speed and controlled balance necessary for writing fast, extremely accurate temperature records. That's because these instruments operate photoelectrically, utilizing an inertialess beam of light, a mirror galvanometer and a phototube. This means more processing efficiency and economy for you!

- SPEED RECORDING: Fast, (3 to 6 seconds) or Slow, (30 to 60 seconds) for speed control and change of pace.
- NO FALSE RECORDS: Prints only when in balance.
- VARIABLE CHART FEED: Adjustable in 9 speeds.
- CONTINUOUS ACTION: Minimum of moving parts.

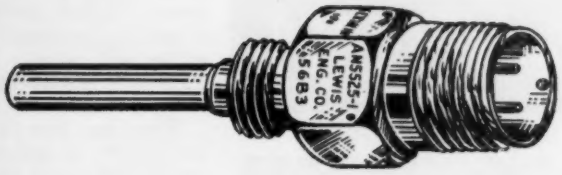
Write for TAG CELECTRAY Pyrometer Catalog 1101 H

C. J. TAGliabue Mfg. Co.
549 Park Avenue Brooklyn 5, N. Y.
Representatives in Principal Cities

Always Specify TAG

SUBSIDIARY OF PORTABLE PRODUCTS CORP.

—THE LEWIS RESISTANCE BULB—



MODEL 56B3
(AN5525-1)

THE LEWIS RESISTANCE BULB MEETS EXACTING SPECIFICATIONS

RESPONSE TIME — Averages 5 seconds from 100°C to 10°C when taken from boiling water to an ice bath.

HERMETICALLY SEALED — Silver Soldered Assembly, by means of modern induction heating methods. The Terminal Pins are sealed in glass to the metal cap as in electronic tubes.

HIGH TEMPERATURE OPERATION — Built to withstand a test temperature of 300°C for one minute. Bulbs model 56B5C and 56B6 will withstand operating temperatures of 500°F for a minimum of 500 hours. Model 56B6D will withstand 300°C for a minimum of 8 hours.

TOUGH — Built to "take it" of Stainless Steel. The stem is of 18-8 type 304 (AMS5560A) and the head is constructed of Type 303 (AMS5640B). Polarizing Pin is of unique construction to prevent bending, twisting, or becoming loose.

STANDARDIZED RESISTANCE Vs. TEMPERATURE — The resistance - Temperature characteristics meet "AN" specifications from —70°C to +200°C, and have been extended to 300°C.

ACCEPTED AS STANDARD BY LEADING AIRFRAME MANUFACTURERS —

These Bulbs are used as standard equipment on the following Aircraft:—

BOEING STRATOCRUISER 377

CONSOLIDATED 240

DOUGLAS DC-6

LOCKHEED CONSTELLATION 49

MARTIN 202 and 303

REPUBLIC RAINBOW RC-2

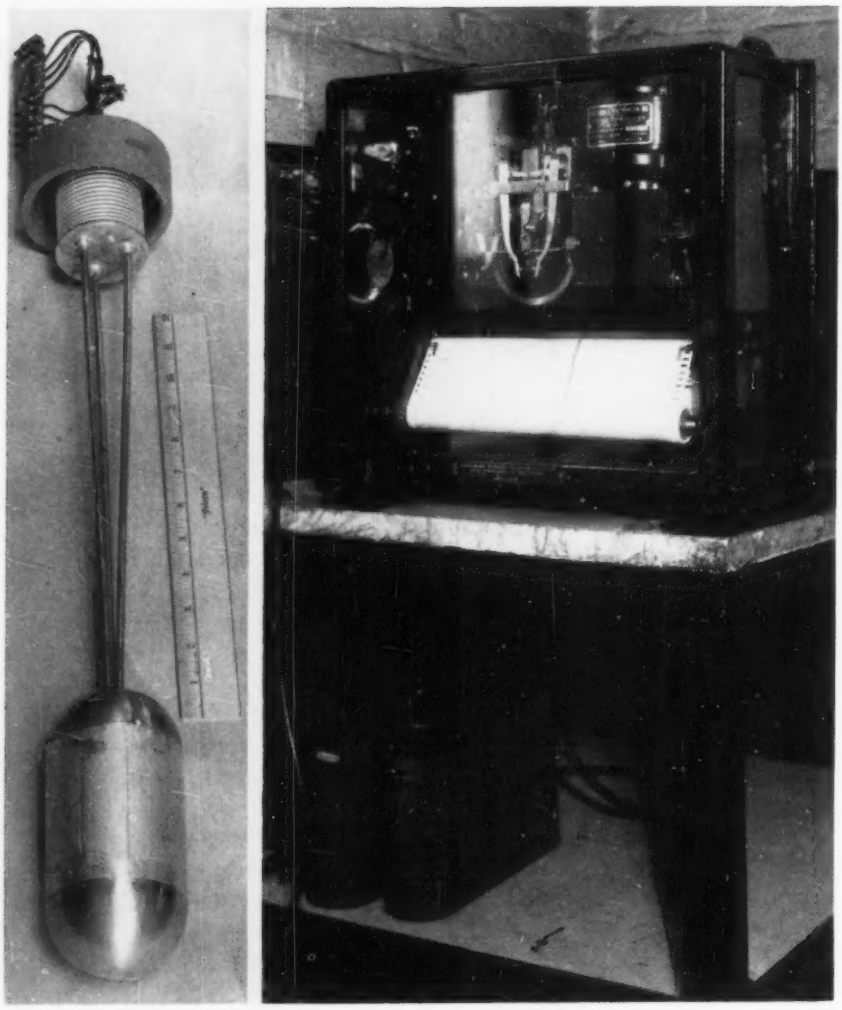
THE LEWIS ENGINEERING CO.

Specialists in Engine Temperature Measurements

NAUGATUCK, CONNECTICUT.

POTENTIOMETERS • • • • • • SELECTOR SWITCHES • • • • • • • • • THERMOCOUPLES • PYROMETERS • • • • • • RESISTANCE THERMOMETERS • • • PROTECTION TUBES •

INSTRUMENTS ON THE MARCH



(Left) Primary element of new flowmeter. The deflection-measuring electric gage is housed in the metal bellows. *(Right)* The recorder and integrator.

Vane-type Flowmeter with Electrical Transmission

NEW YORK CITY. — Engineers of Consolidated Edison Co. have devised a new form of the "vane" or "force" type flow-rate meter for use in studying flow conditions in that combination company's gas mains. Although still in the experimental stage, the device is expected to do away with installation difficulties common in other types of gas flowmeters. As worked out by Consolidated Edison's Test Bureau, the new meter may be inserted in a gas main through a tapped hole. Other meters require that the gas main be cut through unless provision was made at the time the main was put in.

The new flowmeter employs Baldwin-Southwark electrical strain-gage wires 0.001" in diameter which change their resistance to an electrical current as they are extended or compressed. Four such strain gages are mounted in a Wheatstone bridge circuit on a 3" piece of spring steel. The upper end of the steel strip is firmly anchored to the gas main while the other end supports a steel tripod extending into the gas stream. At the end of the extension is a hollow aluminum cylinder closed at either end with a hemispherical cap. This vane is suspended at the center of the gas main.

When gas flow in the main changes, the degree of deflection of the hollow cylinder changes. As the assembly, with the exception of the spring steel, is rigid, the entire motion is transferred to the spring to which the strain gages are attached.

The electrical changes result in a flow of current through a sensitive galvanometer which causes it to deflect. This, in turn, automatically controls a slide wire resistor which restores balance to the galvanometer. A pen mechanically attached to the slide wire indicates the change graphically on a moving chart. The strain produced in the gages is proportional to pressure on the aluminum cylinder and this pressure is proportional to the square of the velocity of the gas stream. A compensating balancing circuit is incorporated in the recorder so that it shows a linear response to velocity changes.

The static-pressure compensation is automatic: a variable shunt resistance incorporated in the measuring circuit of the recorder is operated by a 100" (H_20) pressure gage to vary the recorder constant with changes in the static pressure.

Variations in temperature from 50°F. to 70°F. introduce errors less than 1 percent. Since the gas temperature does not deviate beyond these values, temperature correction is neglected.

The integrator was designed for use with a standard type recorder. The integrator register is friction-driven by a metal disk which rotates at 1 rpm. The register is mounted on a carriage which is mechanically attached to the recorder pen-arm. Changes in gas flow change the position of the pen-arm and register carriage simultaneously, thereby changing the contact point of the friction-driven rotor of the register on the rotating metal disk. As the gas flow increases the radius of the register driving contact on the rotating disk increases, thus increasing the rate of registration.

Cavity Magnetrons Find Peace-time Uses

NEW YORK CITY. — The mighty cavity magnetron — the electron tube that gave American radar its powerful wallop — leads the Western Electric

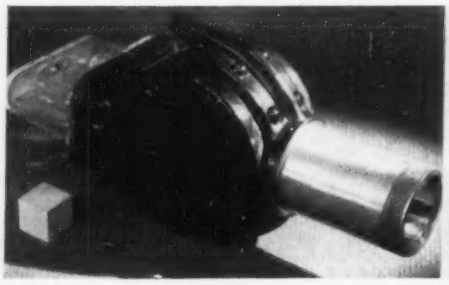


Fig. 1

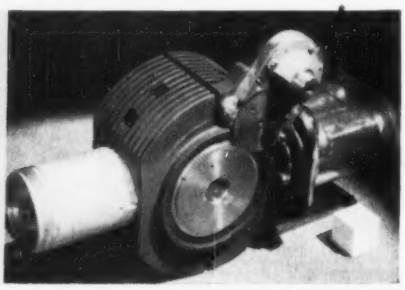
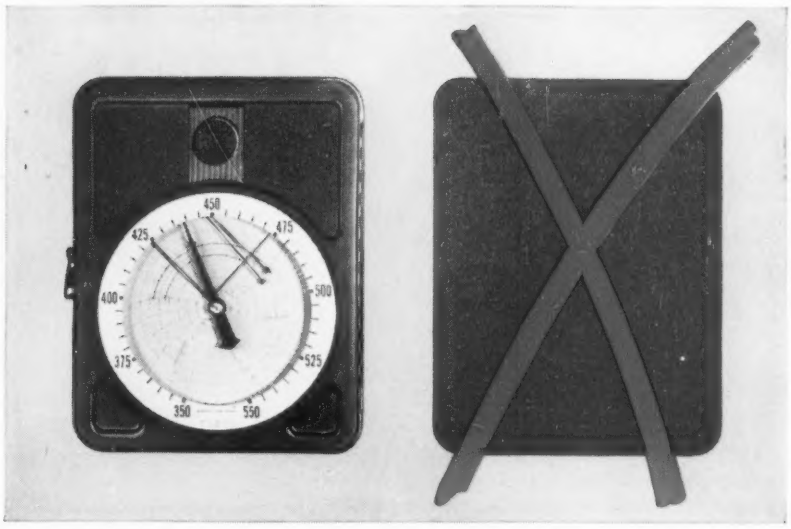


Fig. 2

Save Panel Space with Two Controlling Pyrometers in One Instrument



You can cut control panel space easily by using the Bailey Pyrotron Temperature Controller. This Potentiometer-Pyrometer can be furnished to record and control two separate temperatures at the same time.

Other Unusual Features of Bailey Pyrotron Dual-Temp Controllers

1. **Null-balance measuring systems kept in continuous balance by inertia free electronic detectors and motor control systems.**
2. **Ample power for operation of control and alarm devices provided by reversible slidewire drive motors.**
3. **Usual Galvanometer replaced by sturdy electronic units.**
4. **Conversion of thermocouple emf to a-c by saturable core reactors containing no moving parts.**
5. **Maintenance simplified by easy accessibility and by interchangeable packaged units.**
6. **Careful leveling or protection against usual vibration not necessary.**

● Each control system is actuated by a thermocouple which is always connected to the self-balancing potentiometer circuit. *Each temperature has its own independent system.*

A comparison of related temperatures can be made quickly as both records are on the same chart.

For details on this unusual thermocouple type Recording Controller ask for Bulletin 232. P-12

BAILEY METER COMPANY

1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE	FLOW
PRESSURE	LEVEL
% OXYGEN	DENSITY
% COMBUSTIBLES	RATIO

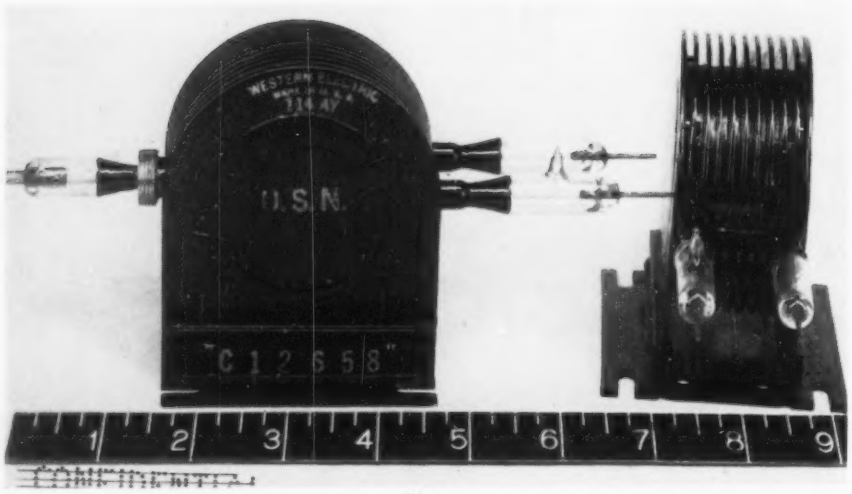


Fig. 3

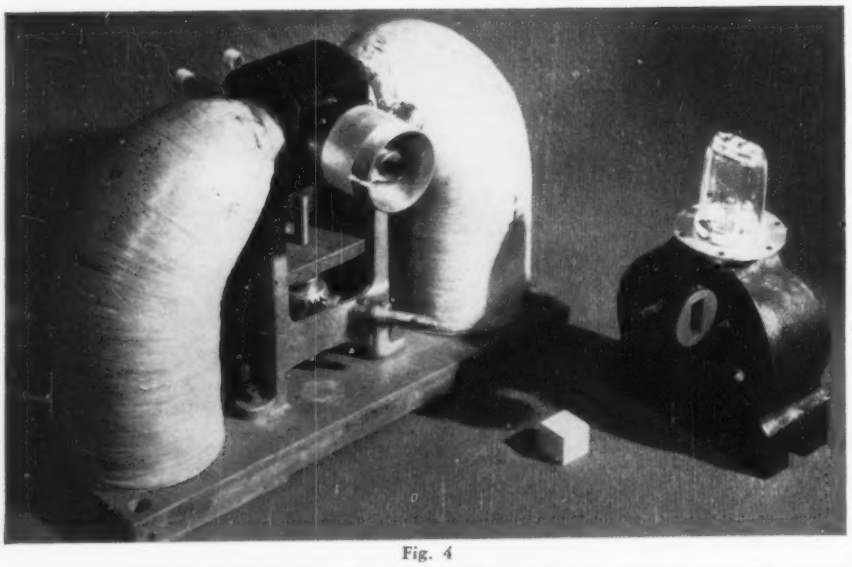


Fig. 4

vacuum-tube display at current expositions. During the war Bell Telephone Laboratories which designed over fifty different types and Western Electric which manufactured thousands of tubes from these designs became the foremost industrial team in the magnetron field.

Consisting of a cylindrical unipotential-heater cathode surrounded by a massive copper anode, the cavity magnetron falls into a two-element classification. Each anode contains a number of resonant cavities shaped in cross-section like keyholes with the thin slots of each feeding into the central chamber. The cavities—in effect resonant circuits—become excited as electrons emitted by the cathode are whirled in the cathode chamber past the slots by the action of an axial magnetic field.

Among the magnetrons shown is the famous 706AY-EY in the S-band (Fig. 1), essentially an improved version of the original magnetron secretly brought to the United States by the British in 1940. In a matter of less than five weeks, Bell Labs had completely tested the tube and constructed five duplicates. One of the *tunable* cavity magnetrons on display is the 5J26 (Fig. 2) designed by Bell Labs to act as replacement for the 4J21 to -30 fixed-frequency series, with which it is mechanically as well as electrically interchangeable. Fig. 3 shows the 714AY designed by Bell Labs to operate in the 3280-3320-Mc. range in the S-band. At the left in Fig. 4, between the magnet poles, is the 720AY-EY S-band fixed-cavity magnetron; at the right the 725A which is unique in that it was the first tube on which the scaling theory was tested in going from S- to X-bands and served as prototype for subsequent X-band work.

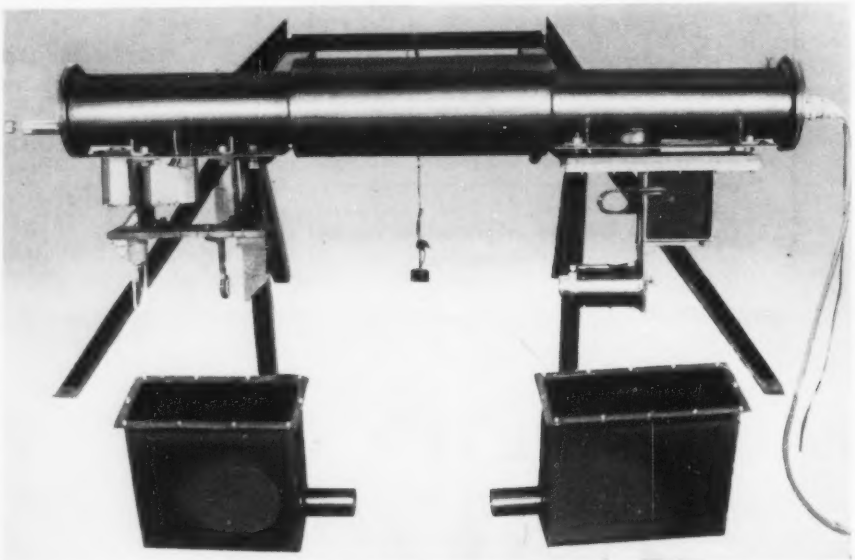
The Absorption-emission Pyrometer: a New Method for Measuring Flame Temperatures

CINCINNATI, Ohio.—Rocket exhaust flames believed to reach temperatures of as much as 4,000°F. can be measured by a new device described here on Oct. 25 at the Thirty-second Annual Meeting of the Optical Society of America, by Donald H. Jacobs, Supervisor of the Long Range Navigation Section of the Aerophysics Laboratory of North American Aviation, Inc.

The problem of measuring the temperature of the exhaust flame of a rocket has proved baffling to engineers for a number of years. Thermocouples are destroyed by the terrific heat. A few measurements have been made by the sodium line reversal method but this offers many serious disadvantages. It requires the addition of special materials to the rocket fuel and only works if the rocket exhaust temperature remains constant for an appreciable period of time. It requires an observer to remain near the motor being measured—an undesirable situation because these motors are likely to blow up.

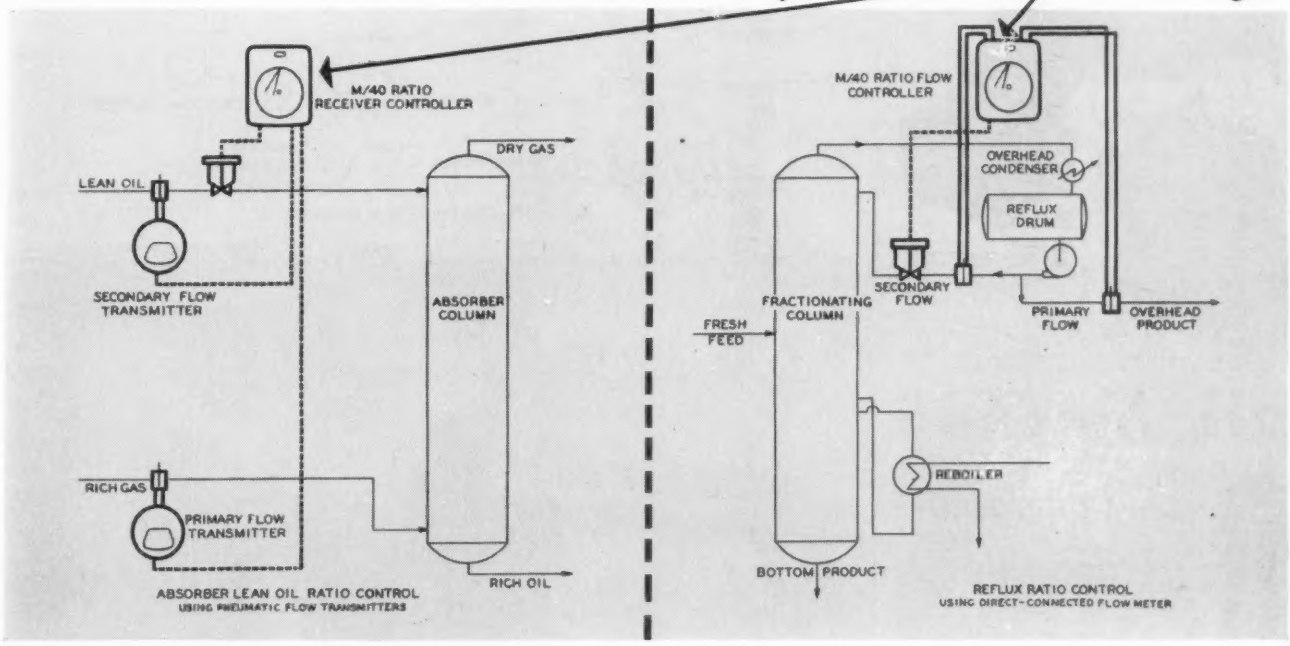
The completely new type of instrument disclosed by Jacobs has been named by him the Absorption-emission Pyrometer.

A light source in the instrument sends a beam of light through the exhaust flame of the rocket and another beam of light from the same source is bypassed around the flame by a series of mirrors. A system of mechanical shutters causes these two beams of light to fall alternately upon a photocell;



Pyrometer with protective covers removed.

KEEPING FLOW OF TWO FLUIDS IN EXACT RATIO...*Automatically*



with FOXBORO Flow-Ratio Controllers on the job

● By controlling the flow of a liquid or gas in unvarying, continuous ratio to that of another, sensitive processes like distillation and absorption can be streamlined to peak efficiency. Every change in the flow of the primary fluid is reflected by a proportional change in the secondary fluid flow, thereby maintaining a constant ratio between the two. The operation is precise, instantaneous, and completely automatic. Liquid level, pressure, and other process variables may similarly be ratio-controlled. (Controllers are also available to ratio more than one secondary flow to a common primary flow.)

The Foxboro Flow-Ratio Controller offers unique advantages both in its measuring system and in its M-40 control mechanism. Its combination of accuracy, sensitivity, flexibility, and simplicity is unrivalled.

The ratio mechanism has been specifically designed to maintain set ratios accurately through the whole range of the instrument. The desired ratio is easily obtained by turning a calibrated thumb wheel visible through the chart plate. The mechanism is a compact, rugged unit that fits into any Model 40 Controller.

Write for detailed information. **The Foxboro Company, 46 Neponset Ave., Foxboro, Mass., U.S.A.**

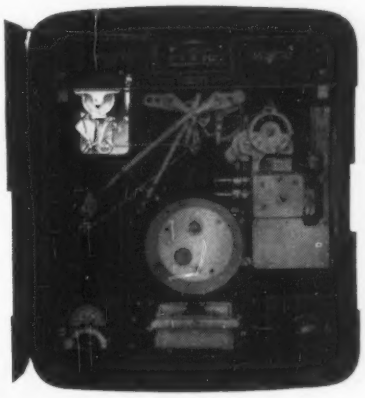
FOXBORO

M-40

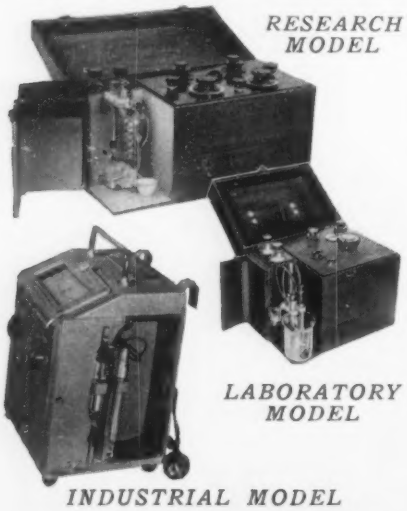
CONTROLLER

THE ONLY CONTROLLER WITH *Permaligned* CONSTRUCTION

Foxboro Flow-Ratio Unit installed in M-40 Controller



CAMBRIDGE



RESEARCH MODEL

LABORATORY MODEL

INDUSTRIAL MODEL

pH METERS

Line-operated—accurate!

The three models illustrated above incorporate many important advantages. All are line-operated from any 110-volt A.C. outlet . . . can be kept turned on continuously to make pH measurements at any time without delays of waiting through warm-up periods. Ruggedly built, portable, they are simple and convenient to use.

Research and Laboratory Models use an electron-ray tube for precise null-point indication . . . sensitive and cannot be injured by mismanipulation.

Industrial Model reads directly in pH values on 0 to 14 pH scale. Specially designed for all-around plant use.

RESEARCH MODEL: Accuracy .02 pH. Range 0 to 14 pH; 0 to 1200 millivolts. Size, 8½" x 10" x 17½"; weight 25 lbs.

LABORATORY MODEL: Accuracy 0.5 pH. Range 0 to 14 pH; 0 to 1000 millivolts. Size, 12¾" x 10½" x 8¾"; weight 17 lbs.

INDUSTRIAL MODEL: Accuracy .10 pH. Range 0 to 14 pH. Size 7" x 8½" x 11¼"; weight 10 lbs.

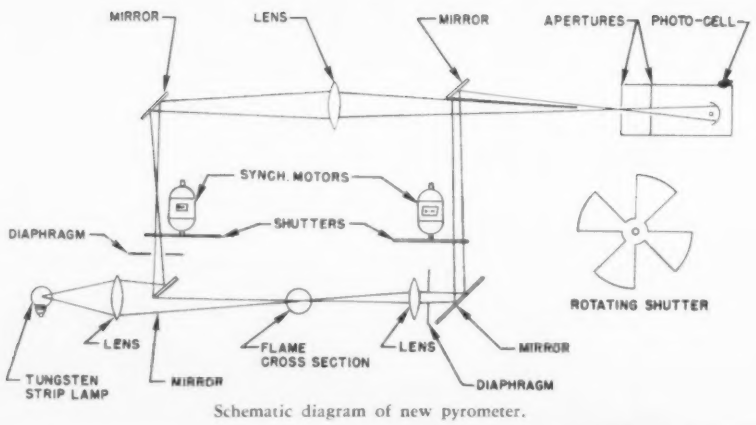
OTHER pH EQUIPMENT: Other line-operated Cambridge pH Equipment includes single- and multi-point Indicators and Recorders.

Write for Bulletin 910-MR

CAMBRIDGE
INSTRUMENT COMPANY INC.
3742 Grand Central Terminal
New York 17, N. Y.

Pioneer Manufacturers of

PRECISION INSTRUMENTS



Schematic diagram of new pyrometer.

Complete working set-up of pyrometer, including electronic components in rack, and recording oscillograph on table at right. The temperature of an acetylene torch flame is being measured.

this photocell is connected to various monitoring, amplifying, and recording circuits. Studies of the theory of this device show that if the brightness of the light source is varied so that the photocell always receives the same amount of light from the beam that passes through the flame and the beam that passes around it, the temperature of the rocket exhaust will bear a known relation to the temperature of the light source.

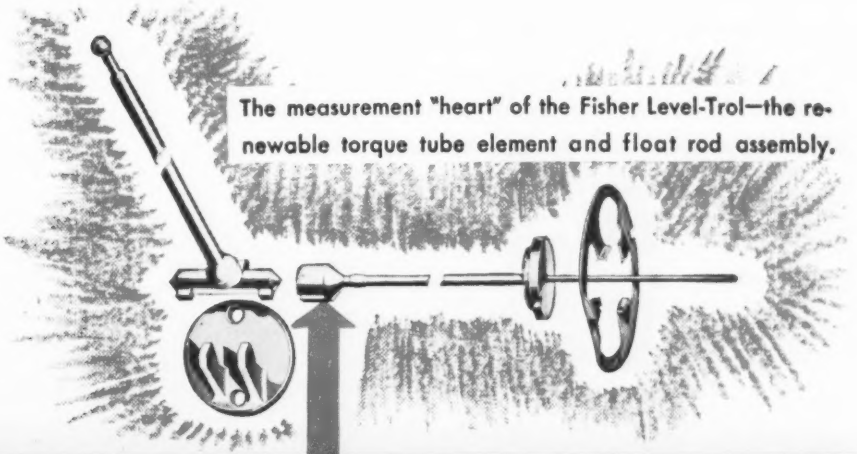
With this instrument it is possible to record automatically and continuously the fluctuations in the temperature of a rocket motor as the motor starts up and runs under various experimental conditions. Provision is included in the instrument for means of making a survey of the change in temperature across various cross-sections of the exhaust. It is not necessary that an instrument operator be in the vicinity of the rocket when it is running.

Five Million Pictures per Second

CINCINNATI, Ohio.—A new motion-picture camera which will take more than five million pictures a second was described here on Oct. 25 at the Thirty-second Annual Meeting of the Optical Society of America, by Dr. Brian O'Brien, Director of the Rochester Institute of Optics at the University of Rochester.

When the motion-picture of a rifle bullet, taken by the new technique, is projected on a screen at the usual speed, it requires a minute to show one inch of the bullet's movement. The camera is ten times as fast as any previously made. Gordon G. Milne, research associate in optics at the Institute, worked with Dr. O'Brien in its development. The following is a summary of the disclosure by Dr. O'Brien and Mr. Milne:

Exposure by conventional means at speeds of several million frames per second would require a film movement through the camera at twenty to fifty times bullet velocities. If, instead, the film is stationary and the image caused to move by means of moving optical parts such as rotating mirrors, the total number of frames and thus the total duration of the motion picture becomes



The measurement "heart" of the Fisher Level-Trol—the renewable torque tube element and float rod assembly.

Announcing

FISHER'S

RENEWABLE INTERCHANGEABLE TORQUE TUBE

NOW STANDARD CONSTRUCTION IN ALL LEVEL-TROLS

The renewable, interchangeable torque tube feature of the Type 249 makes it possible for the operator to exchange or replace the torque tube in a Fisher Level-Trol without dismantling the entire level controller or breaking into pressure piping. All Fisher Level-Trols are now furnished with this improved feature. For full details write for Bulletin F249. Fisher Governor Company, Marshalltown, Iowa.

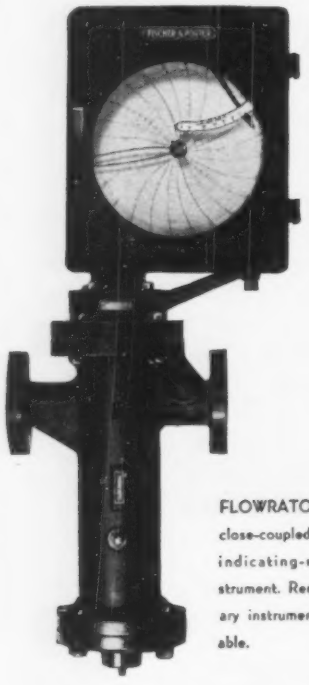
FISHER *Level-Trol*

Mr. Instrument Engineer:

Have you been overlooking a good bet in respect to

PROCESS STEAM METERING

The numerous advantages of the FLOWRATOR meter (formerly called Rotameter) are as valuable for steam measurement as for flow rate measurement of chemicals.



FLOWRATOR meter with close-coupled secondary indicating-recording instrument. Remote secondary instruments are available.

You will find the steam FLOWRATOR instrument competitive in price from ¼" up through 4" size and you will be able to measure the low night flows or end-of-cycle flows accurately. Right down at 5% on the scale readings will be just as valid as at high flows—no square root scale distribution. Furthermore, you won't have to look for a straight run of pipe, or worry about straightening vanes or about condensate pots, overload protection, high pressure loss at high flows.

The F & P "Armored" FLOWRATOR instrument is suitable for complete jacketing with insulation, is available for all industrial operating pressures and temperatures. Its precise integrator will give you a reliable steam use totalization under load fluctuations and low end of scale flows which play havoc with orifice meter accuracy.

Send for Catalog 40 for complete details of "Armored" FLOWRATOR instruments.

FISCHER & PORTER CO.

DEPT. 7Y-5C HATBORO, PA.

FLOWRATOR

TRADEMARK

quite limited. Moreover, rotating mirrors or their equivalent usually make it difficult to secure sufficient illumination on the film for high speeds.

These difficulties are avoided if the image of the rectangular picture is broken up into a series of very narrow strips which are then reassembled, end to end, into one long narrow strip. In the new camera this image dissection is accomplished by a stationary optical system of somewhat unusual properties, and the single long and narrow strip made up of the dissected elements of the original picture is imaged on the negative film as a line so narrow that it is less than the resolving power of the film itself. The film is driven past this line image, and in a direction perpendicular to the line, at the comparatively high speed of 400 fps. This is accomplished by containing the film on the inside of a shallow rotating drum where it is held in position by centrifugal force 16,000 times gravity.

The narrow-strip image is drawn out by the moving film into a streak, and the variations in photographic negative density at any place across this streak contain all the elements of a complete rectangular picture for the particular instant of time represented by the position selected along the streak. The negative film need move by only the width of the narrow slit image to produce a complete new frame of the original rectangular event or picture. Since the camera is shutterless, the motion of the film produces a blurring of the image, but this blurring is limited to the slit width: no more than the resolving power of the negative film itself.

After processing, the negative must be reconstructed into the original rectangular picture by projection back through an optical system similar to that which formed it. This is done by an automatic projection printer which produces an ordinary 16-mm. m-p. print which can be run through an ordinary projector. In the present camera the negative is enlarged ten-fold in printing back to a 16-mm. m-p. frame. Thus the film grain imposes a serious limitation on picture quality although the resolving power secured is adequate for the study of many subjects. The nominal rating of the present camera is five million frames per second, but the behavior is still satisfactory at higher speeds. The exposure time is approximately one seven-millionth of a second but, because of the peculiar arrangements of optical system and film, the interval between frames can be less than the exposure time while still preserving the continuity of the picture.

WHEN A FELLER NEEDS CONTROL BY Putt
AFTER A LOT OF "WIRE PULLING" YOU FINALLY GET SEATS ON THE 50 YARD LINE FOR THE BIG GAME!
HEY POP! TH' PLANT IS ON THE PHONE — THERE'S A BREAKDOWN AT #2 STILL CONTROL AND YOU'RE TO GO AT ONCE!
IDEA BY:
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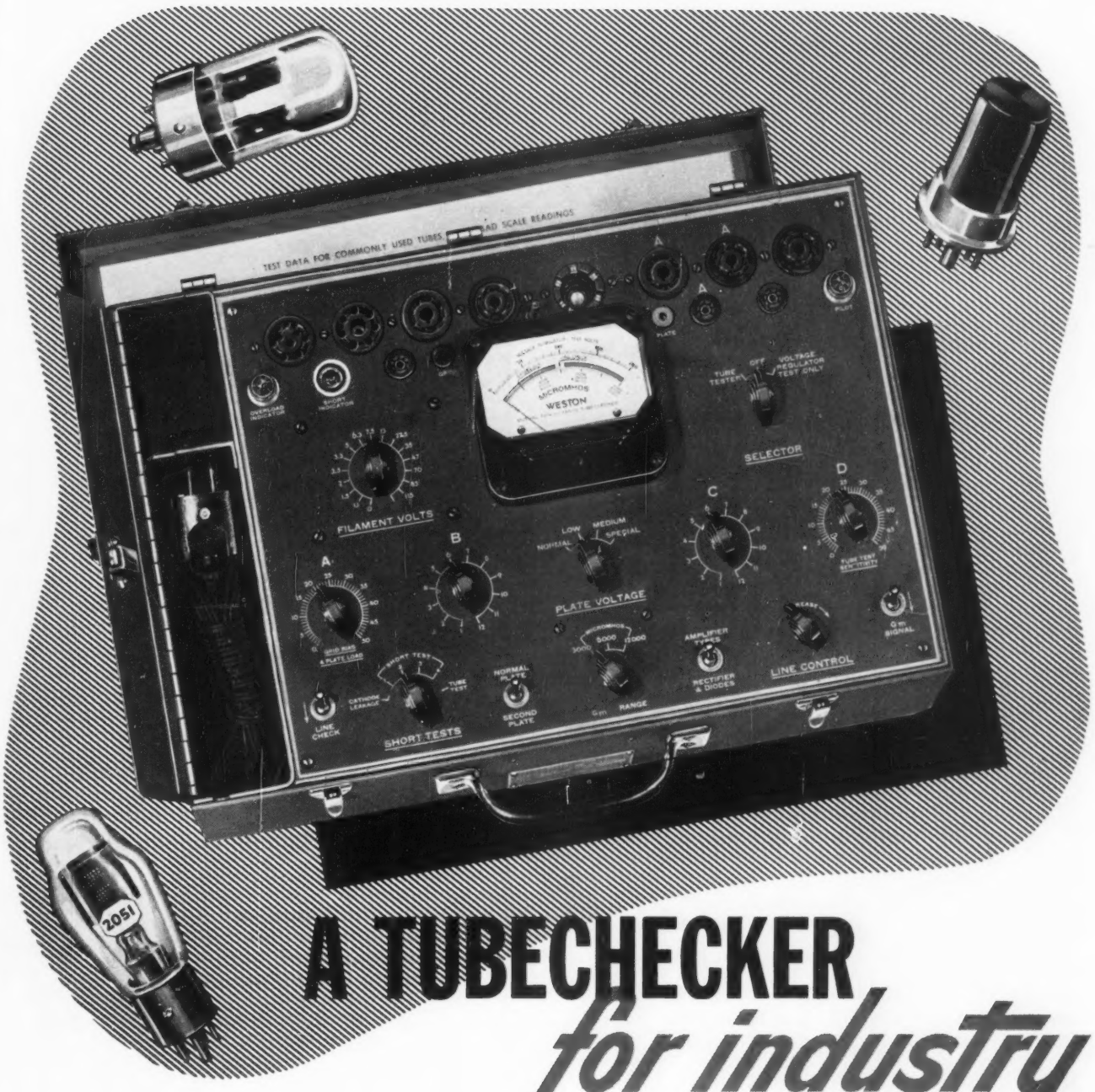
FLUID CONTROLS CO.
PHILADELPHIA, 44, PA.

Instruments pays $5.00 for each idea used. Sender's name and company affiliation will be acknowledged in the cartoon unless we are specifically requested not to do so.
Address Cartoon Dep't, *Instruments*, 1125 Wolfendale St., Pittsburgh 12, Pa.



A TUBECHECKER *for industry*

TESTS: Receiving Tubes, Voltage Regulator Tubes, *low power* Thyratrons

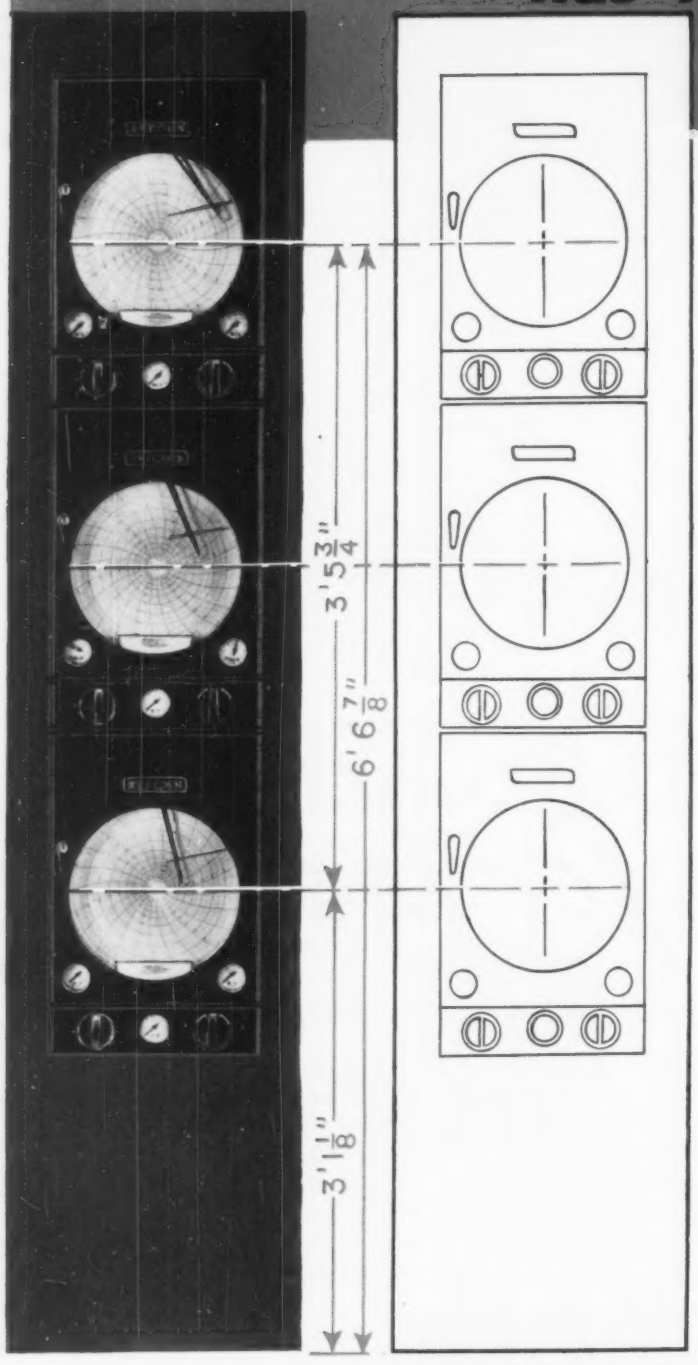
The WESTON Model 798 Mutual Conductance Tubechecker provides, for the first time, adequate tests on voltage regulator tubes, light-duty Thyratrons such as the 884, 885, OA4, 6D4, 2A4, 2050, 2051 in addition to tests on regular receiving tubes. Ranges of 12,000, 6,000, 3,000 micromhos as well as "Good-Bad" indications cover the tube checking requirements of electronic control and radio circuits. Housed in rugged aluminum case to withstand rough usage in shop or field.

For full details consult your local WESTON representative, or write . . . WESTON Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.

WESTON *Instruments*

ALBANY · ATLANTA · BOSTON · BUFFALO · CHARLOTTE · CHICAGO · CINCINNATI · CLEVELAND · DALLAS · DENVER · DETROIT · JACKSONVILLE · KNOXVILLE · LITTLE ROCK · LOS ANGELES · MERIDEN · MINNEAPOLIS · NEWARK NEW ORLEANS · NEW YORK · PHILADELPHIA · PHOENIX · PITTSBURGH · ROCHESTER · SAN FRANCISCO · SEATTLE · ST. LOUIS · SYRACUSE · IN CANADA, NORTHERN ELECTRIC CO., LTD., POWERLITE DEVICES, LTD.

New INTEGRAL CONTROL BY-PASS has the 8 features you specified*



The *Integral* Control By-Pass permits 3-high mounting with easy visibility and accessibility. The pleasing continuous vertical column effect improves the group mounting appearance.

** 103 Chemical and Petroleum Engineers helped design it.*

1 SAVES PANEL SPACE

The Brown *Integral* Control By-Pass permits 3-high mounting without taking any more panel space than is normally occupied by three instruments without by-passes.

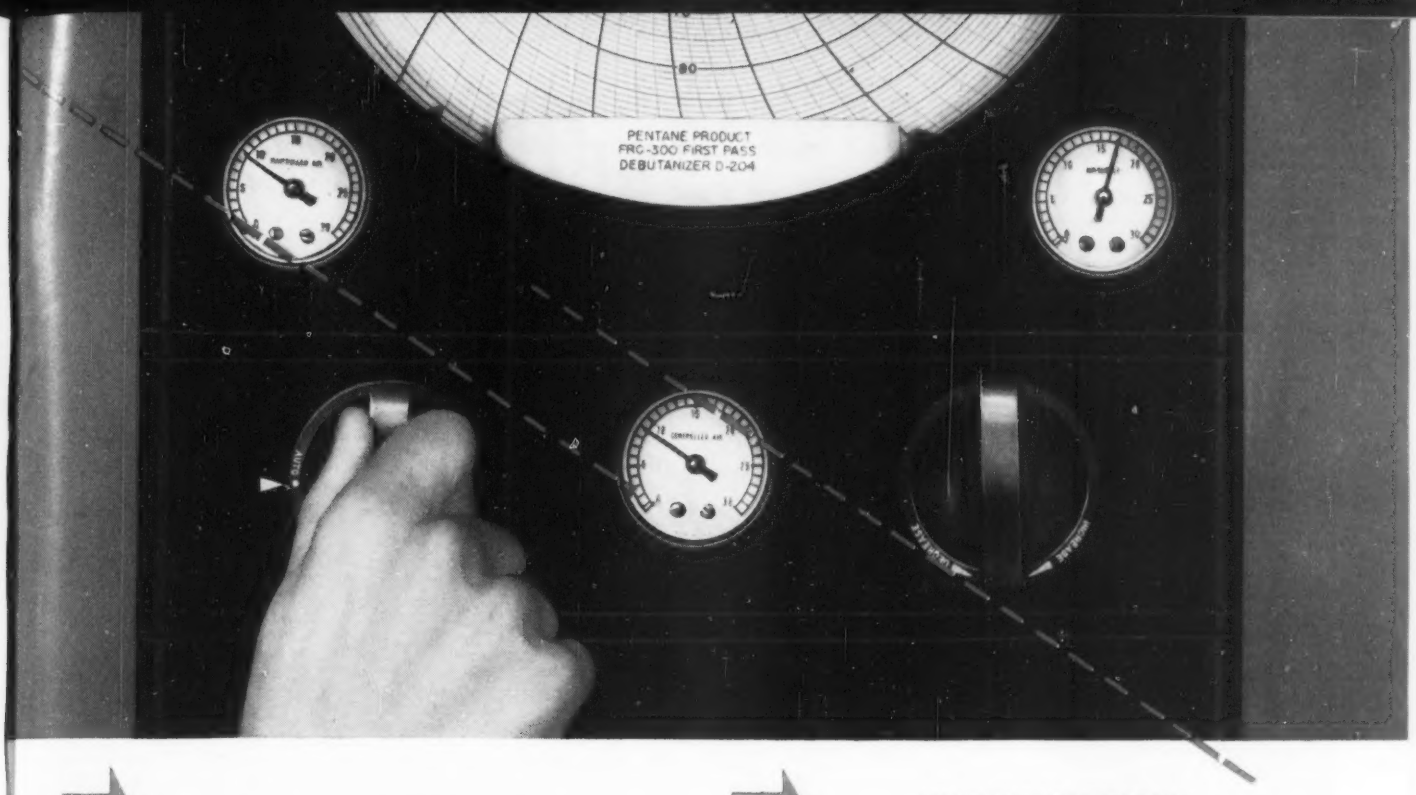
It has been designed with the help of 103 petroleum and chemical engineers to blend desired features into a practical operating form. No compromise has been made in the instrument design nor in the convenience of operating the by-pass.

2 SHIPPED AS A UNIT— Only Two Air Connections Needed

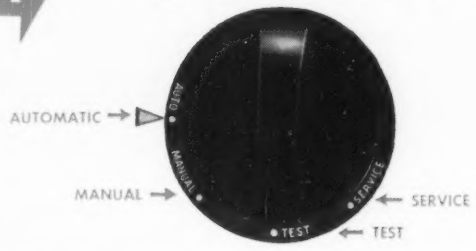
Each instrument and its control by-pass are shipped as one *integral* unit. Because there are normally only two air piping connections to be made on the job, piping is minimized and installation costs are greatly reduced.

3 INSTRUMENTS SEPARATELY REMOVABLE

With the switch in the "service" position, the instrument can be removed, allowing the by-pass to remain for manual control. Disconnection is made by the removal of two screws.



4 FOUR SWITCH POSITIONS



The switching valve employs the plug principle which has proven so satisfactory under wide variations of operating conditions. It provides a bubble-tight, metal-to-metal seat and contains no gaskets to wear nor spring to corrode.

5 NEW PRESSURE REGULATOR ELIMINATES DRIFT

A completely new pressure regulator (operated by the right-hand grip) incorporates two major characteristics: (1) minimum drift and (2) fast response. This new regulator is of the null balance type and can be minutely adjusted for close control settings.

6 ACCESSIBLE WITHOUT OPENING CASE

Switching from "automatic" to "manual" does not require opening of the instrument case. When on "automatic," all switch grips are vertical.

Integral, rather than internal, mounting obviates crowding of components and gives the user flexibility in the selection of control combinations.

7 SWITCHES WITHOUT PROCESS UPSET

Ease of switching from automatic to manual control without process upset is an important operating feature. The "controlled air" gauge (in the instrument) and the "manual" gauge (in the by-pass) are close together and are of the same size and shape. When switching from "automatic" to "manual," it is not necessary to match gauges of different sizes and method of pointer travel. When air pressures on the two gauges are equal, the pointers will have the same inclination and chances of error are minimized. All air gauges are located at the bottom, so that even the top instrument can be set with ease and accuracy.

8 NO OBSOLESCENCE

Current models now in operation are adaptable to the new *Integral* Control By-Pass. Furthermore, working parts such as control units, *Indexets*, actuating elements and other components now familiar to your maintenance force are still used.

WRITE FOR CATALOG 2221

The new *Integral* Control By-Pass is completely described in Catalog No. 2221. A copy will be sent to you without obligation.

THE BROWN INSTRUMENT COMPANY
4482 WAYNE AVENUE, PHILADELPHIA 44, PA.
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.

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Instruments and Controls

FOR THE INDUSTRIES

Wherever you Employ Magnets, Check with us on the Advantages of using

ARNOLD

PERMANENT MAGNETS

As electrical constituents go, permanent magnets are relatively new. They made tremendous advances within the past decade, especially in the communications and aviation industries, and in the general fields of instruments, controls, meters and mechanical holding devices.

Many of these uses were problems that just couldn't be solved until permanent magnet materials were developed to do the job—a work of pioneering to which Arnold contributed a heavy share. Many other applications were those where permanent magnets supplanted older materials because of their inherent ability to save weight, size and production time, as well as greatly improve the performance of the equipment.

To these advantages, Arnold Permanent Magnets add another very important value—standards of quality and uniformity that are unmatched within the industry. Arnold Products are 100% quality-controlled at every step of manufacture. What's more, they're available in all Alnico grades and other types of magnetic materials, in cast or sintered forms, and in any shape, size or degree of finish you need. ● Let's get our engineers together on *your* magnet applications or problems.

THE ARNOLD ENGINEERING CO.

Subsidiary of

ALLEGHENY LUDLUM STEEL CORPORATION

147 East Ontario Street, Chicago 11, Illinois

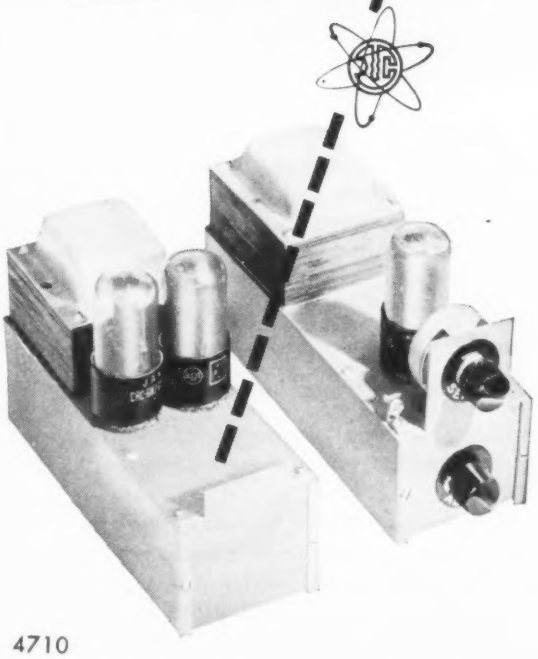
Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS

W&D 1296

Write for Descriptive Literature

Wheelco CAPACILOG

A NEW *Electronic* SCRIBER



Wheelco, in creating the *"ELECTRONIC PRINCIPLE"* for pyrometric Control paved the way for faster, simpler and more accurate industrial Process Regulation.

Years of research, engineering and experience in practical application of Electronic Controls all over the world, now culminate in the production of the WHEELCO CAPACILOG, an electronic recording indicating or controlling instrument.

This simplified "ELECTRONIC SCRIBER" combines the "no-contact" features of the universally accepted Wheelco Capacitrol with a revolutionary mechanical design of rugged construction, perfected to fine watchmakers' precision.

The CAPACILOG is available as a *Deflection, Potentiometer* or *Resistance Thermometer Type Recorder, Recording Controller* or *Indicating Controller.*

CAPACILOG FEATURES

- **Wheelco "Electronic Principle"**
- **Direct Reading**
- **No Converters—No Relays**
- **Plug-In Chassis Design**
- **Multi-Tube Safety Factor**
- **Voltage Selector Plug**
- **Swing-Out Chart**
- **Automatic Chart Reroll**
- **Backlash Breaker**
- **Standard Electronic Tubes**

4710

WHEELCO *Electronic* INSTRUMENTS

Recorders · Controllers · Combustion Safeguards

Wheelco Instruments Company, 833 W. Harrison St. Chicago 7, Ill.

Easy on the eyes!

U. S. Radium Luminescent Dials enable pilots to see better

Leading aircraft-instrument makers choose U. S. Radium dials because of their bright, long-lived luminescence and accurate markings

Above you see one of four types of indicators, equipped with U. S. Radium dials, which are supplied with the Simmonds Pacitor Gauge — a highly reliable, electronic fuel gauge manufactured by Simmonds Aerocessories Inc., New York, and currently being installed in Douglas DC-6, Lockheed Constellation, Consolidated Vultee 240, and other aircraft.

Pilots of the new super-airliners have plenty of instruments to read! To make the dials as legible as possible . . . and especially to eliminate glare at night . . . commercial airlines specify that all letters, numerals, and graduations on scales must be self-luminous.

To meet this specification with assurance of full satisfaction, leading aircraft-instrument manufacturers use U. S. Radium dials and pointers. The bright self-luminous markings — precisely applied — are easy to read in daylight, artificial light, or darkness.

LUMINESCENT DIALS FOR OTHER INSTRUMENTS

U. S. Radium is producing dials for a wide variety of instruments and timepieces — using long-lived luminescent materials in a range of brilliant, standardized colors.

The services which U. S. Radium offers you include (1) designing dials for luminescence; (2) start-to-finish production of luminescent dials, pointers, or other components; (3) application of self-luminous, fluorescent, or phosphorescent materials to existing dials; (4) production of highly precise nonluminescent dials. To find out how any of these services may increase the utility, accuracy, or saleability of *your* instruments, write to *Dept. 19. U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.*

UNITED STATES RADIUM

Luminescent Dials

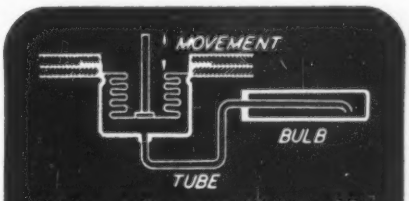
He's sweating out mis-fits . . .

TESTS of Fulton Sylphon custom-made bellows assemblies are tough . . . as you can see in the picture of the thermostat assembly test above. They must meet rigid specifications. If they don't, they're mis-fits—they never leave the factory.

Such extreme care is taken for one reason: to insure that product performance will be completely satisfactory. Nothing less will do.

For over 43 years Fulton Sylphon has specialized in the development and production of metal bellows, bellows assemblies, and bellows devices . . . and has never relaxed its high standards of workmanship. That's why designers and engineers in practically every industry rely on Fulton Sylphon for help in solving problems involving the control of temperatures and pressures.

Perhaps you have a product, or are planning one for which these assemblies are "just the ticket". They do hundreds of jobs—such as opening and closing valves, sealing shafts, sounding warning signals, turning engines on and off. Write our engineers for helpful advice. And send for Catalog VE-1200. It contains a wealth of valuable information and idea-stimulators.



This type bellows assembly is used for controlling temperature. Thermostatic charge confined outside bellows and within cup. Bulb optional. Produced in sizes, types and metals to meet practically any requirement.

Temperature Controls • Bellows Devices • Bellows Assemblies

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We are your Assistants . . . NOT your Competitors . . .

We make no end products. We have no allied branches. These two facts are important to our customers. They can discuss their problems and product designs freely with us, knowing that their confidence will be respected. Thus your problem becomes our problem, and our advantage of 37 years of permanent magnet designing becomes your advantage.

This is only one of the many reasons why The Indiana Steel Products Company is headquarters for Permanent Magnet research, why more than 25,000 individual applications have been developed by our engineers, why we are the world's largest producer of permanent magnets which utilize every conceivable permanent magnet material.

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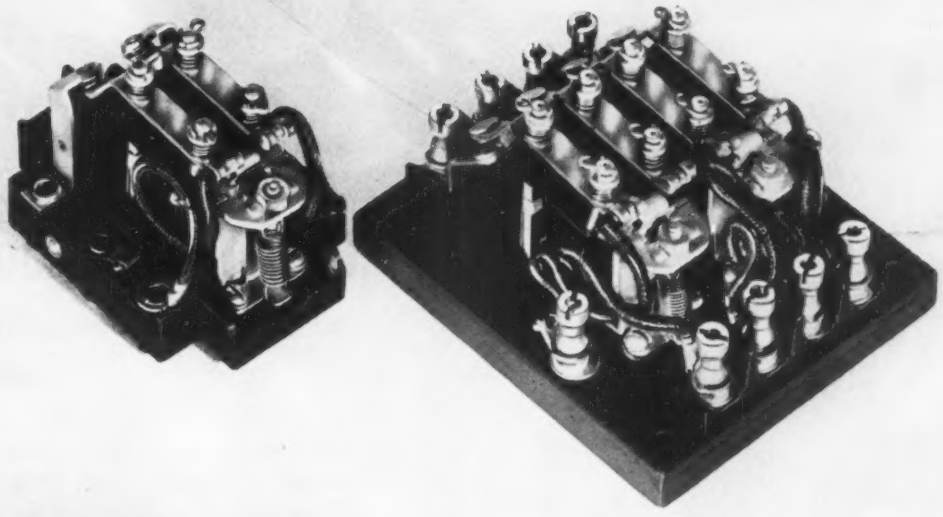
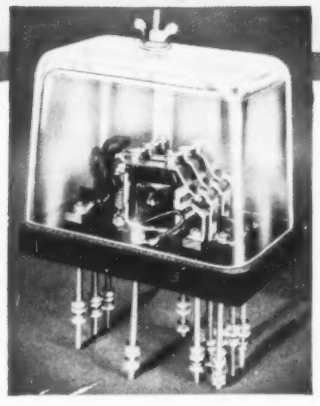
STRUTHERS-DUNN

Midget Relays





Glass enclosed type for switchboard mounting

SMALLEST SIZES CONSISTENT WITH DEPENDABLE OPERATION

• Designed for long, trouble-free performance wherever space, weight or moderate cost are important considerations. Available for a.c. or d.c. use as specified. *Exceptionally quiet on a.c. applications.* Conservative contact ratings (based on heater load values) are:

6 amps. at 115 volts a.c.
3 amps. at 230 volts a.c.
0.5 amp. at 115 volts d.c.

• Underwriters' approved. Individually tested. Ideally suited for built-in applications, control of small motors, heaters, audible and visual signals, lamp control and various other uses. Special adaptations available for radio-frequency, low-voltage loads, audio-frequency loads and other exacting uses.

Write for Struthers-Dunn Midget Relay Bulletin

5,327 RELAY TYPES

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NOW! RONAFLEX

a flexible tubing of 1001 uses

with hi-speed snap-on couplings that save time... cut costs... speed work

Here is a revolutionary new type of tubing with the flexibility of rubber . . . the sturdiness of steel. Ronaflex is a synthetic rubber tubing protected by strong steel braiding cover that provides extreme flexibility, tight free-flowing transmission of air, water, gases, oil, volatiles.

For quick, tight connection, Ronaflex tubing is available with hi-speed snap-on aluminum couplings that resist rust, prevent leakage, save time. Simply snap on, snap off—a one-second operation! Precision-made, they withstand severe vibration and pressures up to 500 p.s.i. without leakage.

Designers, engineers, plant managers will find Ronaflex tubing assemblies ideal for economical use everywhere: fuel and oil lines for engines, machine tool coolant lines, butane-propane gas lines, paint spraying air lines, for rapid testing operations, and countless other applications. Write for complete data. Ronaflex tubing assemblies, manufactured by the Ronaflex Tubing Co., Inc., are distributed exclusively by . . .

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Penflex... HEART OF INDUSTRY'S LIFE LINES

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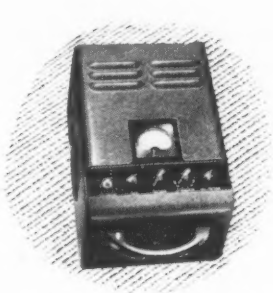
This Oscillograph draws an INSTANT picture of electrical impulses!



Brush Model BL-913 D.C. Amplifier. Well adapted to the measurement of static or dynamic phenomena such as temperature, light, pressures, strains, etc.

Today when saving time costs is so important, your best bet for an *immediate* picture of electrical impulses is with Brush Oscillographs. No more delays with photographic development. *Instantaneous*, permanent, ink-on-paper recordings by Brush Oscillographs make their use almost unlimited. Accurate recordings of strains, pressures and countless electrical phenomena can be made over a frequency range of D.C. to 100 c.p.s. Today Brush Oscillographs are available in Single, Double and Six Channel models. The magnetic Pen Motor is available separately for incorporation into equipment such as medical, geophysical and other highly specialized designs. Whenever desired, recordings may be stopped for notations on chart-paper.

Write today for detailed bulletin.

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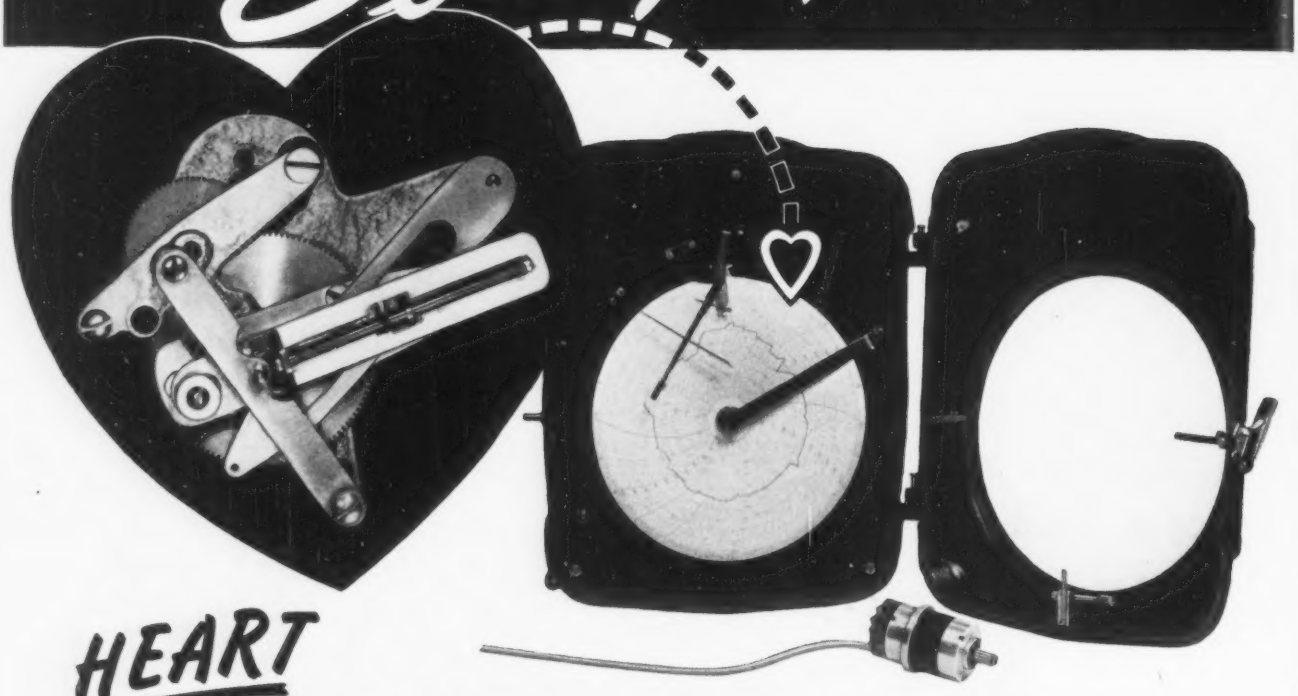
Servograph



HEART OF A *NEW* FIELD OF RECORDER APPLICATIONS

POSITION vs. TIME

● Servograph is a new type graphic recorder utilizing a circular chart with an inking pen which is motivated from a remote point by war proven synchros. Synchro is the U. S. Navy's designation for a special type of self-synchronous motor which provides accurate duplication of motion when two are connected in parallel.

Operating from the receiving synchro is the heart of the Servograph—an extremely accurate variable ratio device which connects to the pen arm. This mechanism makes the Servograph so flexible that a single adjustment will provide full chart coverage with any given rotation within the range of ½ to 10 revolutions. This unusual feature permits accurate recording of any remote variable which can be converted to angular rotation of the transmitting synchro. Included are pressure, temperature, liquid level, and most mechanical movements.

"Records Almost Anything That Is Capable of Being Converted Into Angular Motion"

SERVO-TEK will assist you in applying the Servograph to your particular requirements.

WRITE FOR FREE BULLETIN

SERVO-TEK PRODUCTS CO.
INCORPORATED
Manufacturing Division
CLIFTON, NEW JERSEY

YOUR TELEPHONE TRANSMITTER AND RECEIVER, *voice gateways to the telephone plant, are so essential to satisfactory service that they have been under study in Bell laboratories for seven decades.*

A TELEPHONE RECEIVER is a complex system of electrical and mechanical elements. Its coils, magnets, diaphragm and cap react on each other as they convert the electrical waves of your voice to sound waves. What is the best size for the holes in the ear cap? Will 1/1000th inch greater thickness help a receiver diaphragm to carry your telephone voice more clearly? One way to find out is to build numerous experimental receivers and test them.

But Bell Laboratories have found a shorter way. They built an all-electrical replica, an "equivalent circuit" in which electrical resistance stands for air friction in the cap holes; capacitance corresponds inversely to the stiffness of the diaphragm. Over-all performance of this circuit can be quickly measured and design changes economically explored. Later, a model can be built for final check.

The "equivalent circuit" was pioneered by Bell Telephone Laboratories 25 years ago. It is a useful tool in many Laboratories developments—saving time, saving the cost of machine-tooled models, encouraging experimentation. It is one more example of the way Bell scientists get down to fundamentals as telephone progress continues—and service keeps on improving for all subscribers.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

NORTH AMERICAN

ADJUSTABLE PORT VALVES OPERATED BY ANY TYPE OF CONTROL MOTOR

PROPORTION AND CONTROL THE FLOW OF GASES AND LIQUIDS

The use of North American adjustable port valves is desirable whenever a definite minimum and maximum flow of a medium is required and where it is necessary to vary that flow intermittently or continuously between these limits. They can be used singly, or in pairs when simultaneous and proportional control of two mediums is advantageous.

THE NORTH AMERICAN MANUFACTURING COMPANY

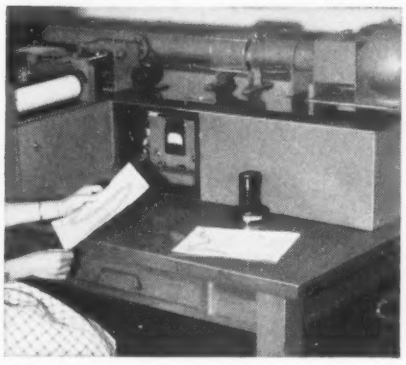
MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

BRANCH OFFICES *with* FIELD ENGINEERS *in* PRINCIPAL CITIES

How GE Specialized Testing Equipment *Cuts Production Costs*

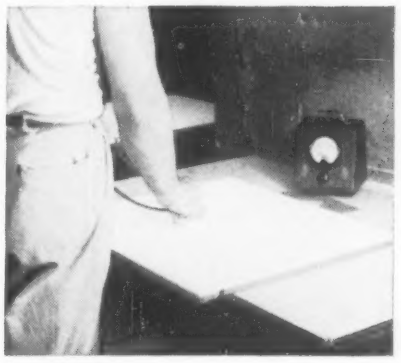
Viscosimeter Saves Its Cost in One Month

By enabling the Cleveland Steel Barrel Company to improve control and uniformity of the finish on its steel shipping containers, the Zahn viscosimeter saved its first cost in a month. Rejects from stickiness and the need for repaint jobs were eliminated. The Zahn viscosimeter has many similar applications for the users of varnish, lacquer, japan, syrups, and other liquids. Write for Bulletin GEA-3618C.



Spectrophotometer Pays Its Way in One Project

Ten years ago, the Harshaw Chemical Company developed a new opacifier, Uverite, to replace tin oxide. On this project, a G-E recording spectrophotometer more than paid for itself. But the important news is this: Harshaw's chemists say it has been paying for itself repeatedly since then by giving quick, permanent results for color analysis, comparison work, etc. Write for Bulletin GEA-3680A.



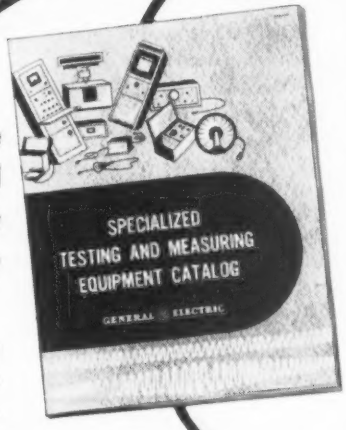
Thickness Gage Saves $600 Monthly

In determining the amount of white enamel needed on stove parts by its thickness, this gage saves Florence Stove Company $600 monthly. This includes savings from the reduction of rejects and from speeding up the enameling process. G-E thickness gages measure the thickness of any nonmagnetic material on a magnetic iron or steel base. Range: from 0.00005 to 0.75 inch. Write for Bulletin GEA-4363A.

These are three of many cases where General Electric laboratory equipments cut costs in laboratory and factory procedures.

If you have a specialized testing problem, we shall be glad to investigate for an effective and economical answer. Apparatus Department, General Electric Company, Schenectady 5, N. Y.

NEW FREE CATALOG FOR REFERENCE AND ORDERING



This new SPECIALIZED TESTING AND MEASURING EQUIPMENT CATALOG contains 44 pages of the latest in measuring and testing equipment, giving application, description, specifications, photographs, prices, and how to order. Here, in easy-to-use form, information is assembled about approximately 100 equipments. If you can use a catalog of this type, fill out the coupon completely and send it today.

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GENERAL ELECTRIC

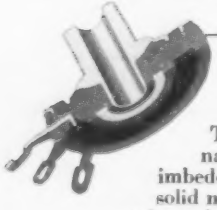
New OHMITE

2-Watt Molded Composition Potentiometer

A high quality unit... withstands heat, cold, moisture and severe service

• Nothing like this potentiometer has ever been offered to the industrial market through the radio parts distributor. It is primarily a high quality unit—built to last. The resistor material is not of the paint or film type, but is solid molded. Heat, cold, or moisture cannot affect it. Wear does not change its contact resistance, hence the control retains its very low noise characteristic. Furthermore, it has a 2-watt rating with a good safety factor.

Sold only through Ohmite distributors



Terminals are imbedded in solid molded resistor element.

Specifications

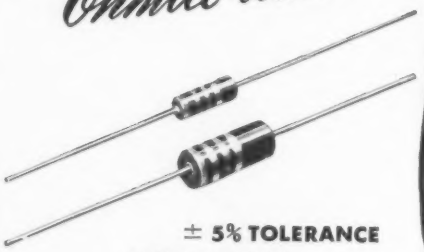
RESISTANCE: Max resistance values, 50 ohms to 5 megohms in linear taper. Also logarithmic tapers in limited ranges.

POWER: Max continuous rating at 100% rotation —2.25; 50%—2.0; 25%—1.3.

VOLTAGE: Max cont. across entire resistor, 500 volts provided wattage rating is met.

AMBIENT TEMP: From —60 C to + 100 C.

...another NEW Ohmite item



± 5% TOLERANCE

LITTLE DEVIL COMPOSITION RESISTORS

• These popular resistors are now available in ½- and 1-watt sizes in tolerances of ±5%—in addition to the standard ±10% units. The resistance and wattage are clearly marked on every unit. *Sold only through Ohmite Jobbers.*

OHMITE MANUFACTURING CO.

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RHEOSTATS • RESISTORS • TAP SWITCHES • CHOKES • ATTENUATORS

DU MONT *announces the new . . .*

CONTINUOUS-MOTION/SINGLE-IMAGE OSCILLOGRAPH-RECORD CAMERA Type 314

AVAILABLE NOW FOR DELIVERY FROM STOCK IN LIMITED QUANTITIES

SPECIFICATIONS...

- ✓ Wide range of film speeds (3600 to 1) — from 1 inch per minute to 5 feet per second.
- ✓ Instantaneous change from low- to high-speed recording.
- ✓ Calibrated electronic speed control (in./min. and in./sec.)
- ✓ Quickly detached to free oscillograph, or for use with other oscillographs.
- ✓ Fixed-focus f/2.8 or f/1.5 lens for medium- or high-speed recording.
- ✓ Capacity of 100 feet of 35 mm. film or paper; provision for 1000 feet if required. Film footage indicator.
- ✓ Operates independently of ambient light. Simultaneous viewing and recording of trace.
- ✓ Self-illustrated data card for labeling given "takes" directly on film. Provision for timing markers.

Applicable to ALL 5-inch cathode-ray oscillographs!

To meet the need for permanent records of complex phenomena, Du Mont proudly presents a camera capable of photographing all types of traces — high or low frequency; periodic or aperiodic; continuous-motion or single-image; and for time intervals up to 200 hours.

The new Du Mont Type 314 Oscillograph-Record Camera* provides all users of cathode-ray oscillographs with a useful, simple, practical recording means. It opens the way for precise quantitative measurements. It permits direct comparisons of traces recorded at different times under varying conditions.

For maximum convenience, the mounting, operation and dismounting of this camera are reduced to simplest terms consistent with the requirements and practices of the widest range of oscillograph users.

* * *

*Manufactured for Du Mont by Fairchild Camera and Instrument Co.

Descriptive literature on request.

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DUMONT *Precision Electronics & Television*

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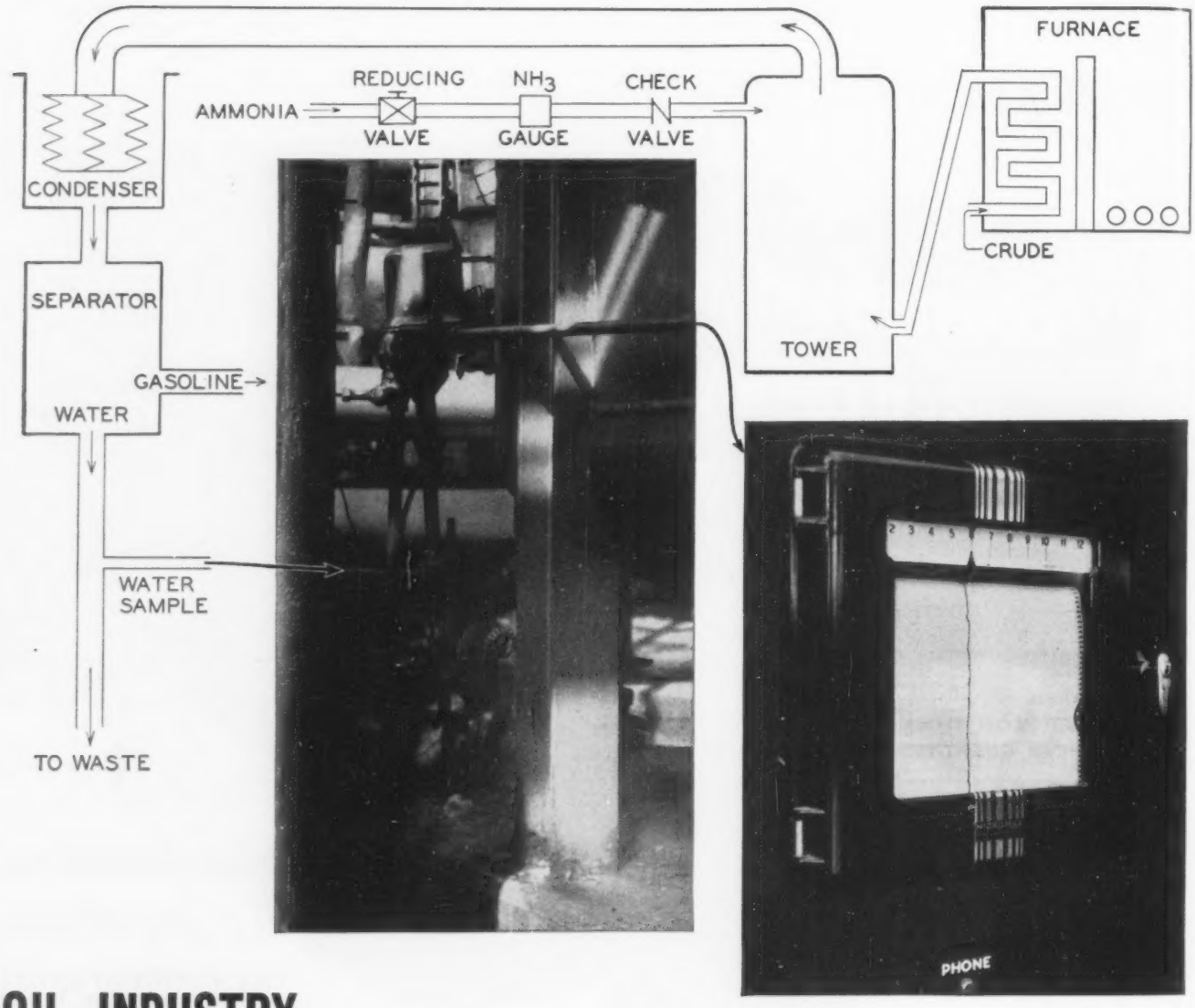

OIL INDUSTRY
FIGHTS CORROSION WITH MICROMAX pH RECORDERS

One of corrosion's most effective enemies in many refineries is the Micromax Recorder which continuously shows the pH of water at various plant locations. At present, these are the three principal opportunities:

1. Dehydrator water. A Micromax record of this pH helps prevent both overtreatment and undertreatment of acid crudes.

2. Hydrofluoric Acid processes. Here any leak affects pH instantly, and the sensitivity and dependability of Micromax Recorders make them particularly valuable for prompt detection of leaks and the heading-off of resultant corrosion.

3. Power-plant and process water supply. Here the Micromax instrument is often an Automatic pH Controller, and its function is not only to help prevent corrosion of the entire plant's water-piping system but also to guide in the proper treatment of water for power plant use.

Complete Equipment Plus Experience

By selecting Micromax pH equipment a chemical engineer secures a completely integrated installation — researched, designed and built by a single organization, and backed by experience which enables us to make prompt and complete recommendations for any type of pH instrumentation. For details, write Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia 44, Pa.

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EDITORIALS

By M. F. BEHAR

Electron Tubes in Instrumentation

IT is an old saying, yet an apt one, that no scientific discovery is evil in itself but that some men put some discoveries to evil uses.

It often has been said also that most men—not some but most—become unduly fascinated by some discoveries, inventions or mere new gadgets. At this season, for example, most fathers who have bought mechanical toys for their sons are playing with these toys.

We're not against electron tubes; on the contrary, we're convinced that they represent one of the greatest modern developments. We're not against their use as components of measurement and automatic-control circuits; on the contrary, we're convinced that this use of tubes benefits science and industry.

Likewise we are FOR electronics—just as we are for statics, kinematics, kinetics, dynamics, hydraulics, pneumatics, acoustics, optics . . . and electrostatics and electrokinetics and good old electromagnetism! Which is to say that we are not against but FOR

Electronics. 70.05.005. That branch of science and technology which relates to the conduction of electricity through gases or in vacuo. [American Standard Definitions of Electrical Terms.]

We're NOT against the MEN—the play-with-toys men, the perfectly normal men—who use electron tubes indiscriminately and sometimes dangerously.

But we're against the unwise or risky use of electronic components. Likewise we're against the unwise or hazardous use of ANY component whether mechanical or hydraulic or pneumatic . . . or electromechanical or magneto-optic or photoconductive or piezoelectric or magnetostrictive or thermoelectric or electrochemical . . . or capacitive or resistive or inductive or reactive!

By indiscriminate or unwise or injudicious use, we mean for example the use of a $500 remote position-repeating system when a piece of string would do, or the use of a piece of string when logical considerations dictate the use of a high-precision repeater (mechanical or electrical) regardless of cost.

By hazardous or dangerous or risky use of components we refer, of course, to the application—the process or machine or weapon—on which the instruments are installed; and to the consequences of malfunction or failure of the instruments.

If the application is a high-pressure boiler in a power plant in the middle of a town, or a large-scale chemical process, or a blast furnace, or an anti-aircraft installation, then every component of every measurement and automatic-control system must be as nearly infallible as human ingenuity can make it. No type of component is absolutely infallible. All fail sooner or later. The two important facts to be borne in mind are: (1) the great majority of NON-electronic components do NOT fail unpredictably or unexpectedly; (2) the great majority of electron tubes fail unpredictably or unexpectedly. Even the high-priced tubes made for telephone-repeater and railway signal service fail after UNPREDICTABLE periods.

It would not be fair to call electron tubes "unreliable." The right word is "unpredictable." No amount of care and ingenuity in manufacture can prevent tubes going bad—even on the stock shelf a few months or days after final inspection: it's simply a matter of mathematical probability arising from the great number of factors entering in tube construction assembly, etc.*

Of vital importance is the question of what happens to a controlled process upon failure of the power supply which is utilized by the control instruments to operate the valves, dampers, etc. This question has two distinct aspects:

(1) The first is the enormous advantage of pneumatic control systems in the event of power failures: NOTHING happens to the controlled process when the interruption is brief, because the compressed-air storage tanks have enough capacity for several minutes' operation of all valves, dampers, etc. (In vitally-important installations, capacity is simply increased to take care of hours of operation).

(2) IN GENERAL, electrical, pneumatic, hydraulic or mechanical components simply take up where they left off when the power failed. The instruments usually remain "in position" and resume without attention (other than minor jobs such as turning charts by hand to the right time). IN GENERAL, electronic components cause severe upsets. Only electronic components require WARMING-UP after a power failure. This sometimes is extremely serious because if an over-eager operator connects the controlled circuit too soon, two or more not-yet-warm tubes will function momentarily as an oscillatory circuit.

A prominent user told us that his hair almost turned white on several occasions when he feared that operators would not have the patience to wait—and in some applications the necessary virtue is not patience but bravery, for even a few seconds' power interruption is risky and the prolongation of no-control by reason of tube warm-up might cause a disaster with heavy loss of life. *Theoretically*, it is possible to design for *any* application a circuit whereby oscillations after resumption of power will be prevented: in practice this has been done in only a relatively few cases.

Electron tubes are here to stay—in automatic-control systems as well as in a multitude of other devices. They perform certain functions supremely well. Therefore, to try to drive them out of our field would be injudicious as well as futile. To drive them out of those AUTOMATIC-CONTROL applications where they DON'T belong is the obvious duty of influential instrument engineers.

Electron-tube functions, such as rectification, amplification or oscillation, can be performed by non-electronic devices. (Even radio stations and radio receiving sets could be built without tubes.) The undeniable advantages of tubes drove out of radio the rotary oscillator, the crystal set and other non-electronic equivalents. Now, however, a reversal of the trend is discernible—not in radio but in instrument engineering—at present only in a few critical applications such as automatic-control systems where tubes are being replaced by magnetic components. What magnetic components? One important but little-known* category will be described in our next issue. —MFB

*Read- "Tube Failures in ENIAC" by F. R. Michael of Penn'a Univ. in the Oct. 1947 *Electronics*, page 116-119. This article reports statistics on 644 "tubes removed" from the 18,800-tube computer. Read especially the editorial note on page 116—for which *Instruments* salutes *Electronics*.

*Though dating back to Dr. Alexanderson's 1916 patent.

Machine-tool Instrumentation

IN Chicago the instrument exposition of September 8-12 at the Stevens Hotel was followed by the machine-tool exposition Sept. 17-26 at the 12-acre Dodge-Chicago plant—the only building in the country that could accommodate under one roof three miles of aisles where 2021 machine tools in actual operation were viewed by a hundred thousand visitors (175,827 admittances counted at entrances).

This largest industrial exposition ever held has received the publicity it so well deserves. One note needs to be emphasized. It is AUTOMATICITY THROUGH INSTRUMENTATION.

In the last five or six years the automatization of machining operations has made more progress than in the preceding five or six decades. One reason is that only in the last five or six years has the Science of Instrumentation been deliberately applied to these *operations* —much in the same manner and by much the same intellectual efforts as it had been applied to *processes* in the last twenty years. Instead of crude triggers, limit stops, etc., actuating clutches, switches, reversing gears, etc., one sees genuine measuring elements commanding prime relays and even scientifically-designed servomechanisms.

In addition to automatization there is an enormous increase in the application of monitoring instruments: of measuring instruments such as ammeters, of integrating instruments such as watt-hour meters, and even of recording instruments, some on the machines themselves, others centralized on panels in superintendents' offices. Which is to say that there has also been progress in the application of totalizing and telemetering instrumentation.

Congratulations to the machine-tool industry. —MFB

Application of Viscosity Measurement in Petroleum Refining Operations*

By D. J. POMPEO, Shell Development Company, Emeryville, Calif.

ABSTRACT. The application of viscosity measurements to the control of petroleum refining operation as applied to lubricating oils, fuel oils, diesel fuels, jet fuels and various types of cut-back asphalt is discussed. Places where automatic recording and control instruments for continuous measurement of viscosity would aid in the control of refinery processes making for more efficient operation are also indicated.

IN the refining of products derived from petroleum one of the important properties requiring close control is the viscosity of the materials to meet specification. Specifically, viscosity measurement applies to such liquids as lubricating oils, fuel oils, diesel fuels, jet fuels, hydraulic oils, certain types of greases, and various types of cut back asphalts used for road construction. Viscosity measurement is a significant factor also in connection with other operations in the winning and handling of petroleum. In the drilling for oil the viscosity of drilling muds is important in determining the performance of circulating fluid in rotary drilling operations; in the pumping of crude oil from the well and also in the transportation by pipe line of the crude, viscosity plays an important role in the efficiency with which the oil is obtained from the ground and the ease with which it can be pumped to its destination for refining operations.

Viscosity Defined

The absolute dynamic viscosity (η) of a fluid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the planes is filled with the fluid in question and one of the planes moves with unit velocity in its own plane relative to that of the other. The viscosity is expressed in dyne-seconds per cm.^{2} and has the dimensions, ($ML^{-1}T^{-1}$) in the cgs system. The absolute kinematic viscosity (ν) is equal to the quotient of absolute dynamic viscosity by the density of the fluid.

Viscosity Index

Another important property of a lubricating oil is the viscosity index.[1] This is an empirical number indicating the effect of change in temperature on the viscosity. A low viscosity index signifies a relatively large change in viscosity with temperature; and vice versa. Thus, in a lubricating oil for use in internal combustion engines a desired characteristic is that in cold weather the viscosity is not too high to assure ease in starting and to afford proper lubrication of various parts. Conversely, in hot weather the oil should not be too thin or have too low a viscosity in order to obtain good engine performance.

Determination of Viscosity in the Laboratory

In a typical refinery control laboratory investigation has shown that approximately 300 determinations of viscosity are made per day (24 hours) in order to control the quality of the various products and to see that specifications are met. Most of the determinations (about 90%) are made on lubricating oils and the remainder (10%) on asphalts, fuel oils and on diesel oils to a lesser degree. From this it is clear that considerable effort and time are spent on this determination alone—aside from other necessary tests, such as flash point, pour point, color and gravity of the various products to meet specifications. Kinematic viscosities are usually determined in the laboratory on lubricating oils and dark oils at temperatures of 100°F., 130°F. and 210°F. using the capillary type instruments; while for the determination of the viscosity of asphaltic type materials, where extreme accuracy is not too important, the Saybolt type of instrument is used at temperatures of 77, 122, 140 and 180°F.

Effect of Temperature on Viscosity

The accurate control of temperature is an important factor to be considered in the measurement of viscosity. This is true regardless of the type of instrument used; whether it is of the capillary type for kinematic viscosity work, or of the Saybolt type. The effect of temperature on viscosities of various types of oils is illustrated in the data of Table I of Cannon and Heidrich[2] which is reproduced herewith for the reader's convenience.

From the data in Table I it is seen that to obtain an accuracy of 1% in a viscosity measurement for oil A the temperature should be controlled to 0.3°F. in the range of 80-100°F. and to about 0.7°F. for the range of 180 to 210°F. In the case of Oil D, however, temperature must be controlled much more closely (about 0.1 and 0.36°F.) to obtain 1% accuracy for the equivalent temperature range. The accuracy obtainable by the kinematic viscometer, according to the ASTM Method D 445, is of the order of 0.2%; but here the temperature should be controlled to at least 0.05°F. to meet the requirements of this test.

TABLE I—EFFECT OF TEMPERATURE ON VISCOSITY

Oil	Viscosity in Centistokes at				Average % change in Vis. per °F. change in Temp.	
	210°F.	180°F.	100°F.	80°F.	100-80	210-180
A	4.36	6.16	24.95	41.9	3.4	1.38
B	4.36	6.48	34.08	64.9	4.5	1.62
C	15.8	25.68	176.3	365.0	5.4	2.1
D	15.8	29.12	362.0	957.0	8.2	2.8

Manufacture of Lubricating Oil

Crude oil as obtained from a well contains the lubricating oil which has to be separated and refined to be of use. The first step in the distillation of crude separates the various component fractions from the lighter to the heavier, such as gasoline, kerosene, fuel oil (gas oil), lubricating oil and the residue asphalt. The lubricating oil fraction is next vacuum distilled to obtain closer boiling components having definite ranges of viscosity.

In a typical refinery distilling of 15,000 bbls. per day as many as five fractions are obtained as indicated in Table II.

TABLE II—VARIOUS FRACTIONS OBTAINED FROM A LUBRICATING OIL DISTILLATION COLUMN

	S.U.S. at 100°F.	S.U.S. at 210°F.	Approx. Temp. °F.
Reflux Cut	67	...	370
Light Cut	246	...	410
Cut 1	...	60	490
Cut 2	...	114	495
Cut 3	...	225	500

A side stream from the various cuts is diverted to a control house where an operator periodically checks the viscos-

*Presented at the Second Annual Conference of the Instrument Society of America, Stevens Hotel, Chicago, Ill., Sept. 8-12, 1947.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

(1) *ASTM Standards on Petroleum Products and Lubricants.* American Society for Testing Materials. 260 Broad Street, Philadelphia, Penna.

(2) *Petroleum Refiner*, Vol. 26, February 1947, page 123.

ity with a Saybolt instrument. At this point the measurement of viscosity is an aid to the operator in properly controlling the column. The control laboratory rechecks the samples as obtained from storage tanks before the oil is pumped to the next stage of the refining process.

The lubricating oil fractions so obtained are not suitable as quality lubricants because they contain undesirable components (unsaturated compounds, resins, aromatics and asphalt formers) which produce an oil having a wide variation in viscosity with changes in temperature. One of the methods which is extensively used for removing these undesirable components is solvent refining, with furfural[3] as the extraction agent. Such extraction results in an oil having good viscosity-temperature relationships. Control of the extraction process is accomplished by sending samples to the laboratory and the viscosity is measured at two temperatures (100 and 210°F.) from which the viscosity index is calculated. In this connection it may be mentioned that a measurement of refractive index[4] of the treated oil can be correlated to the viscosity index. However, this measurement depends on the type of crude being processed; thus a change in the crude requires a different value of refractive index to obtain correlation with viscosity index. While refractive-index measurement is an indirect means for determining viscosity index, its measurement has a distinct advantage for plant control, the reason being that the test can be made with an Abbé refractometer by the operator and, if necessary, corrective measures applied without the need of obtaining laboratory results. The latter procedure is time-consuming, especially when the viscosities at two temperatures need to be measured to calculate viscosity index.

Where paraffinic crudes are used, the solvent-refined oil contains enough wax to make it unsuitable for use over a wide temperature range and this must be removed so that the oil will flow freely at low temperatures. In this case the viscosity of oil as well as its pour point is measured as a means of controlling the dewaxing process.

Blending Refinery Stocks

A number of refinery operations require the blending of various lubricating stocks to viscosity and viscosity index specifications. For example, a light or neutral stock may be blended with a heavy or bright stock to yield a particular grade of motor oil. Blending is done by mixing two or more oils in either kettles, tanks, bleachers, or homogenizers which, with the exception of the latter, are equipped with steam coils for heating, and either air or mechanical mixers for stirring. It is necessary for the control laboratory to determine the viscosity or viscosity index of the blends to ensure proper quality before the material is pumped to drums, cars or storage. In these operations considerable thought is being given to automatic blending devices and means for continuous determination of viscosity, as this will reduce the need for expensive storage capacity, aid in better control of the process and decrease labor costs of analysis.

Similarly, it is necessary to blend fuel oil and road oils. A specific example is in the blending of a fuel oil of 800 to 1200 seconds viscosity (Furol at 122°F.) with a lighter fraction to yield a product of 125 seconds viscosity for storage. Blending by means of gravity measurements is not a satisfactory means of control because the viscosity of the material is a limiting factor in meeting specifications.

Need for Continuous Recording Viscometers

In the foregoing discussion it will be noted that no mention is made of either direct-indicating or -recording viscometer instruments for the automatic control of processes. At present, except in a few isolated cases[5] such instruments which can be satisfactorily used in a refinery are practically nonexistent. The impetus given to the development of specialized instruments in the past few years will no doubt change this condition because of the need for improving quality of products and decreasing operating costs. It is well recognized that one way of attaining this objective is the adaptation of automatic-control instruments to the control of a process.

The places where automatic instruments would be useful to the control of process variables are briefly summarized:

1. At the control house where the lubricating oil fractions are obtained. At this point an accuracy of 1% to 2% in a determination is probably sufficient for the purpose because the oil requires further processing.

2. At solvent refining and dewaxing plants. In this case the measurement of viscosity index is important and the viscosity must be measured quite accurately in order to obtain a good value for the index. Indirect methods, such as continuous measurement of refractive index, may be used to obtain a measure of viscosity index.

3. At the compound house where the lubricating oil is blended. Especially would this be important if continuous blending operations were developed because viscosity measurement would be required soon after the mixing took place.

4. At pump houses where road oils are blended and asphalts are pumped to tank cars, trucks or barges.

From these considerations it is plain that much work remains to be done in the development of specialized instruments for indicating or recording of viscosity and viscosity index to obtain more efficient control of refinery processes. A knowledge of the process, the variables to be encountered and the accuracies to be achieved in the measurement is essential to produce a workable instrument.

Acknowledgment

Appreciation is expressed to Shell Oil Company, Incorporated for permission to use information regarding certain of their refinery operations and to Messrs. J. G. Kerley and E. F. Tesche for helpful discussions.

(3) W. E. Skelton, *Oil and Gas Journal*, February 22, 1947, page 137.

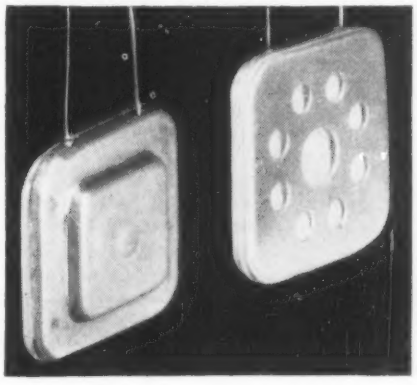
(4) G. H. von Fuchs and A. P. Anderson, *Industrial and Engineering Chemistry*, Vol. 29, March 1937, page 319.

(5) The Fischer and Porter Company, Hatboro, Penna., market a continuous recording viscometer which may have application to certain refinery operations.

INSTRUMENTS ON THE MARCH

(Continued from page 982)

WRIST-WATCH RADIO.—Originally a fantasy in Dick Tracy strips, then realized by the National Bureau of Standards, it depends upon tiny components made by Tibbetts Industries of Camden, Maine, whose "HS-41" square microphone (illustrated) is the world's smallest (1.03" square and 0.21" thick) for its output—49 db-volt/dyne/cm.^{2}.



Boston Instrument Society

The Boston Instrument Society held its second dinner-meeting of the season at the Graduate House of M.I.T. on October 29.

President E. R. Hoffman introduced as the after-dinner speaker Secretary Richard Rimbach of the Instrument Society of America, who gave a preview of the 1948 I.S.A. Exhibition to be held in Philadelphia and announced that plans were being considered for an exhibition at Mechanics Hall, Boston, in 1952.

The technical lecture was given by Mr. J. M. Devine of the Baird Associates, Cambridge, Mass., who spoke on Infrared Spectrometry, its principles and its applications.

The next meeting will be held Wednesday, December 3 at the Colonial Beacon Oil Refinery, Everett, Mass.

—J. H. Condon